Ares I-X Mission Management Office (MMO) Integrated Master Schedule (IMS)



Ares I-X

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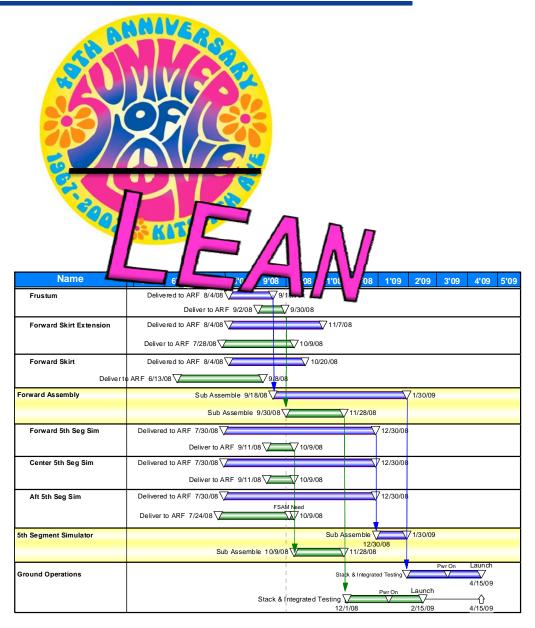




Chance Encounter in The Summer of Lean











Ares I-X Flight Test Objectives





- Demonstrate <u>control of a dynamically</u> <u>similar</u>, integrated Ares I/Orion, using Ares I relevant ascent control algorithms
- Perform an <u>in-flight separation/staging</u> <u>event</u> between a Ares I-similar First Stage and a representative Upper Stage
- Demonstrate <u>assembly and recovery</u> of a new Ares I-like <u>First Stage element</u> at KSC
- Demonstrate First Stage separation sequencing, and quantify First Stage atmospheric entry dynamics, and parachute performance
- Characterize <u>magnitude of integrated</u> <u>vehicle roll torque</u> throughout First Stage flight



The Mission and The Name



The Mission Evolves

- ◆ Late 2005 Team starts to take shape
- ◆ Early 2006 Scope and Cost Creep
- Cancelled
- May 2006 Revived as a relevant, cost & schedule effective flight test
- ◆Apr 2007 1st Lean Event& Project Re-org

The Name Evolves

DFT

ADFT

ADFT 1

ADFT 0

Ares 1

Ares I-1

Ares I-X

~Feb 2007



First Lean Event





A Lean Team gathered at LaRC



IMS Before 1st Lean Event



- A confederation of Level 3, 4, & 5 elements
- Complex board structure
- ◆ The rhetoric of how to best integrate the IMS had to battle with intra- and inter-center politics
 - More energy expended to break through barriers than actually building a good schedule
 - Lack of trust
- No mission-level margin
- Not all elements working in Primavera
- Proper integration of the schedule was not going to happen.
- IMS integrations was done manually
- ◆ Many very talented people working hard to make it work

The First Lean Event was a pivotal point in schedule integration



1st Lean Event Recommendations to CxCB

Control Boards

- - Up to 4 boards (Contractor, Elemen Troject)
 - FTINU mod could have been cone in significantly less time (40 60 %)
 - Benefits include increase in productivity and/or cost savings

Rework Cycles (expected)

- Current State high probability of rework
 - Examples: FTINU, T-0 umbilical, vehicle stabilization, etc.
- Ideal State eliminate rework cycles
 - Integration up-front leads to ½ time reduction

Schedule Margin

- Ideal State Add ~45 to 60 business days of margin Provide incentives for contractors and civil service records.

Priorities

- Current State unclear/everyone marching to a direct drummer
 Ideal State consistent



Ares I-X Org After First Lean Event



A Level 2 Project with IPT's

Safety & Mission Assurance (S&MA)

TBD

Ares I-X Mission Management Office

Mission Manager, Bob Ess
Deputy, MSFC, Steve Davis
Deputy, KSC, Carol Scott
CxP Liaison, TBD
Budget Analyst, JSC/TBD
Project Integration, TBD
Administrative Assistants
Support Staff

Chief Engineers

Joe Brunty/MSFC TBD/KSC

Systems Engineering & Integration (SE&I)

Integrated Product Teams (IPTs)

Ground
Operations
(GO)
Jon Cowart/KSC

First Stage

Chris Calfee/MSFC

Upper Stage
Simulator
(USS)
Vince Bilardo/GRC

Avionics and DFI

Kevin Flynn/MSFC

Roll Control System (RoCS)

Ron Unger/MSFC

CM/LAS Simulator

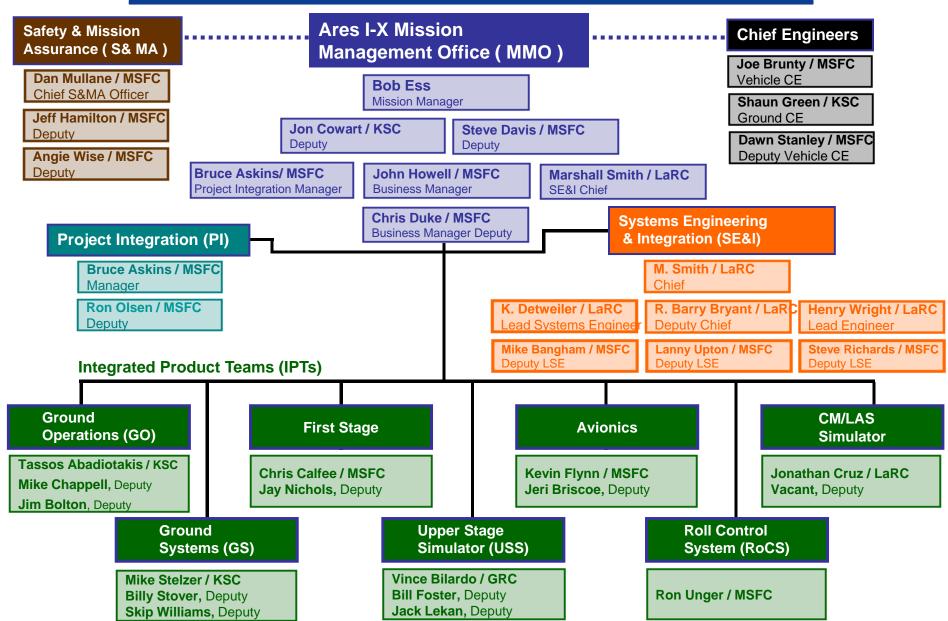
Brian Beaton/LaRC





Ares I-X Organization at Launch







The Summer of Lean





Goal: 60 Days Schedule Margin

- ◆ First Stage Promontory, Utah
- Avionics Denver, CO
- Roll Control Huntsville, AL
- ◆ SE&I Hampton, VA
- Upper Stage Cleveland, OH (attended by local participants and facilitator only)
- Ground Ops/Ground Systems Cape Canaveral, FL



Summer of Love vs. Lean



Love





Lean







Lean Teams







The Lean Machine



Developed a regular process for Schedule Lean Events

- Before Event
 - Lots of pre-planning and working with facilitators
 - Set schedule reduction goals for each area
 - Scoped the event
 - Identify key participants
 - Had local participants prepare current state
- At the Event Monday Noon Friday Noon
 - Kick-off and set the tone and pace
 - Informal report-outs mid-day & end of day
 - Current state
 - Ideal state
 - Future state
 - Incorporate IMS changes and verify savings ASAP
 - Document key enablers for improving the process
 - Final report out to champion
- After Event
 - Incorporate changes to IMS and baseline
 - Confirm that the detailed IMS matches the savings identified.
 - Follow-up on enablers (tracked as action items for the project)

Core Team – at all events

- Leader Steve Davis
- Facilitator Mark Adrian
- Integrator Ron Olsen
- Scheduler Keith Heitzman
- Strategic Participants



Primavera Pilot – It Works



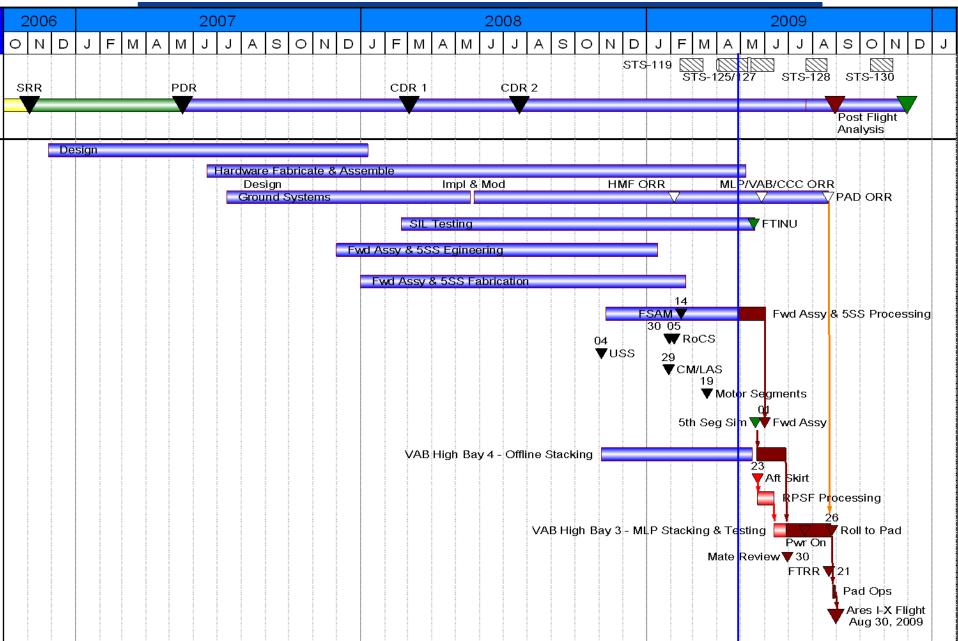
- Primavera kicked-off by Constellation Program (CxP) in early 2006
- CxP wanted 3 projects to test Primavera
 - Schedule Primavera Project Management (PM)
 - EVM Primavera Cost Management (CM)
- Some growing pains early in implementation
 - Primavera consultants provided to help get it going
 - Most PM issues due to how it was set-up in ICE
 - Deleted activities resurrected
 - Printers disappeared
 - Trouble developing reports
 - CM issues seemed to be a combination of network and software issues
 - CM was Abandoned
- Required training and a culture change
- ◆ The Schedule Tool (PM) worked as expected
- Had some issues with integration KSC used their own Primavera Database

A real-time integrated schedule would have been impossible without Primavera



Schedule Architecture & Reporting Examples







Schedule Architecture



- Used Internet-based schedule environment that allowed the entire mission to work in one logically tied, integrated, and live schedule
 - Max 15 primary schedulers with 9 in Primavera
 - 9 companies
 - 6 geographic locations
 - 1 IMS covering entire scope of mission
- Schedules 3 Levels of Detail:
 - Detailed IMS (Primavera) detailed integration (~2,800 lines)
 - Summary IMS (Primavera) logically tied to the Detailed IMS and is where the MMO manages schedule (~600 lines)
 - Executive Summary IMS 1 page quick-look
 - Two versions of Summary IMS:
 - Baseline Version
 - Current Version
- ◆ Summary IMS Developed by MMO from a Mission Perspective

 Managed IMS to the Right Level



Example of Detailed IMS to Summary IMS links



Activity	ID	A - 1': '1 - K1			
		Activity Name	Start	Finish	2006 2007 2008
Are	s I-X F	light Test Vehicle	08-Aug-06 A	29-Aug-08	
А	3000	ATVC Kickoff	08-Aug-06 A		<u> </u>
А	18120	ATVC DET IO PWA Elec. Design	13-Sep-06 A	01-Oct-07	
А	3020	ATVC FPGA DET Design	18-Sep-06 A	01-Oct-07	→
А	3030	ATVC Design - Breadboard	20-Oct-06 A	18-Apr-07 A	
А	18140	ATVC DET Pwr Sply I/F (PSI) PWA Elec. D	01-Nov-06 A	01-Oct-07	→
А	18150	ATVC Chassis Design	02-Nov-06 A	12-Oct-07	
А	18160	ATVC DET MIB Design	07-Nov-06 A	01-Oct-07	
А	3080	ATVC Design - Proto-board	11-Dec-06 A	24-Jul-07 A	
А	18130	ATVC SRR/PDR	13-Dec-06 A		
А	18170	ATVC Proto BdTest (MSFC)	15-Jun-07 A		
А	18180	ATVC CDR	25-Jun-07 A	26-Jun-07 A	<u>-</u> -
А	18190	ATVC Det Board Build & Test	06-Aug-07 A	10-Oct-07	
А	18210	ATVC Sys Test, Intgr $\&ShipDET1$ (Denver	04-Oct-07*	31-Oct-07	
А	18240	ATVC (DET 1) SIL Unit Delivery	31-Oct-07		 - -7
А	18220	ATVC QU Board Build & Test	05-Dec-07*	16-Jan-08	
А	18200	ATVC Flight Board Build & Test	05-Dec-07*	11-Feb-08	<u> </u>
А	18260	ATVC Sys Test, Intgr - Qual	30-Jan-08*	07-Jul-08	
А	18230	ATVC Qual Test Readiness Review(QTRR)	01-Feb-08*		
А	18250	Qual Test Start	01-Feb-08*		L -
А	18270	ATVC Sys Test, Intgr & Ship - DFT-1	02-May-08*	31-Jul-08	
А	18280	ATVC Sys Test, Intgr & Ship - DFT-1 Spare	28-May-08*	29-Aug-08	· · · · · · · · · · · · · · · · · · ·
А	18300	Qual Test Completion	07-Jul-08		
А	18290	ATVC Flight Unit 1 (Ares I-X) Delivery	31-Jul-08		
Ares I-X Summary Schedule			13-Sep-06 A	30-Jul-08	
А	23830	ATVC Design, Fab, Test	13-Sep-06 A	30-Jul-08	-



Schedule Management and Baseline Control Summary IMS



- ◆ There are three reasons to propose a revision to the Baseline IMS to the XCB:
 - When a controlled milestone slips and cannot be recovered
 - When there is a major scope change (+/-) to the mission
 - When the Baseline IMS and Current IMS have diverged to the point that warrants a complete re-baselining
- Proposed Baseline Changes were analyzed by the Schedule Working Group (SWG) and then brought to the XCB by the SWG
- The Current IMS was statused weekly.
 - Variances quickly calculated
 - Baseline variances more than 10 days are analyzed and documented.
 - Any change to controlled milestones analyzed first
- Higher level control milestones such as the FTRR and Launch Date taken to Level 2 - CxCB and Level 1 - DPMC

Discipline and Control managing Baseline and Current IMS





Sample IPT Status in Summary IMS (RoCS)



\ctiv	rity ID	Activity Name	Start	Finish	Variance - BL Project	Variance - 7 BL Project	ONDJ	2008 20 F M A M J J A S O N D J F N
A	ARES I-X-SUM	Ares I-X Summary Schedule	19-Sep-07 A	23-Sep-08	0d	0d		
	ARES I-X-SUM	S Summary	19-Sep-07 A	23-Sep-08	0d	0d		
	ARES I-X-SUI	M.S.40 RoCS	19-Sep-07 A	23-Sep-08	0d	0d		
	ARES I-X-SUM	I.S.40.2 RoCS Reviews	03-Dec-07 A	12-Sep-08	0d	0d		
	A8270	CDR Board - RoCS	03-Dec-07 A		0d	0d	♦	
	A8460	RoCS - Pre-Ship / Acceptance Review		12-Sep-08*	0d	0d		
П	ARES I-X-SUM	I.S.40.3 Hardware Acquisition	19-Sep-07 A	17-Jan-08 A	0d	-6d		
	A8440	Unit 8 Disassembled (for engine)	19-Sep-07 A	10-Oct-07 A	0d	0d	*	
	A13010	Unit 9 Disassembled (for engine/option)	14-Nov-07 A	06-Dec-07 A	-2d	2d	-	
	A13020	Unit 10 Disassembled (for engine/option)	18-Dec-07 A	17-Jan-08 A	-6d	-6d	-	
	ARES I-X-SUM	I.S.40.4 RoCS Build	03-Mar-08	12-Aug-08	-81d	-23d		
	A8450	RoCS Build - Qual Unit	03-Mar-08*	26-Mar-08	-81d	-36d		- 🖰 -20d, -18d
П	A8330	RoCS Build - Flight Unit 1	17-Mar-08*	10-Jun-08	-81d	-82d		20d, -20d
	A8340	RoCS Build - Flight Unit 2	17-Mar-08*	10-Jun-08	-31d	21 d		-20d, -20d
ı	A21080	RoCS Build - Flight Unit 3 (Spare Unit)	28-May-08*	12-Aug-08	-82d	-23d		-20d, -13d
П	ARES I-X-SUM	I.S.40.5 Test	31-Mar-08	19-Sep-08	-38d	-10d		
	A8490	RoCS Qual Unit Pyro Test	31-Mar-08*	04-Apr-08	-38d	-38d		•
П	A8500	Cold Flow Test	31-Mar-08*	04-Apr-08	-38d	-38d		- ♦ -20d,-20d
	A8520	RoCS Deliver Qual Unit for Fit Check at GRC	02-Jun-08*		0d	0d		9
	A8510	RoCS - Acceptance Testing - Flight Unit (1)	11-Jun-08*	09-Jul-08	-82d	-62d		
	A21090	RoCS - Acceptance Testing - Flight Unit (2)	11-Jun-08*	09-Jul-08	21d	41 d		-20d, -20d
	A21100	RoCS - Acceptance Testing - Flight Unit (3)	22-Aug-08*	19-Sep-08	-30d	-10d		- -20d, -20d
	ARES I-X-SUM	I.S.40.7 Deliver to SIL (LM - Denver)	05-Oct-07 A	05-Oct-07 A	0d	0d		
	A24380	Ship/ Deliver to Lockheed for SIL Testing (RoCS Valve	05-Oct-07 A		0d	0d	*	
	ARES I-X-SUM	I.S.40.6 Deliver to KSC	22-Sep-08	23-Sep-08	0d	0d		
	A8530	RoCS Arrival at KSC (Directly to HMF)		22-Sep-08*	0d	0d		8
	A8560	RoCS - RoCS Unloading / Receiving / Inspection	23-Sep-08	23-Sep-08	0d	0d		



Sample Stoplight Chart



Milestone	TIM Milestone Completion Date	Status	Last % Current % Complete		Comments/Threats		
Super Stack 1		Υ	CRITICAL PATH FOR UPPER STAGE BUILD UP				
B On Dock	1/31	Complete	100	100			
A On Dock	2/6	Complete	100	100			
B Fit Check	2/12	Complete	100	100			
A Fit Check	2/14	Complete	100	100			
5 th S S to HB4	4/08	Υ	0	0	Potential slip of delivery to 4/10		
RoCS Propellant Loading in HMF	3/2	R	10	10	Acceptance Review 3/10, Fairing modification required, propellant servicing delayed to 3/13		
RoCS B to HB4	3/17	R	0	0	Delayed propellant servicing, milestone 3/27		
RoCS A to HB4	3/26	R	0	0	Delayed propellant servicing, milestone 4/7		
DFI Test Config 1 GRC Stack 1,2,3	4/8	G	0	0	Additional IS-1/RoCS DFI Installation, milestone 3/28, need GSE to support a 3/23 start		
Stack 1 IS-1/2 B/U Complete	4/17	Υ	0	0	Delayed propellant servicing, milestone 4/21		
IS-1/2/RoCS W&CG	4/20	Υ	0	0	Delayed propellant servicing, milestone 4/22		
FWD Assy to HB4	4/15	R	0	0	Milestone slip to a NET delivery of 4/30		
DFI Test Config 3 Stack 1	4/27	Υ	0	0	Late delivery, milestone U/R		
Modal Test	4/27	Y	0	0	Late delivery, milestone U/R		
Stack 1 B/U Complete	5/2	Υ	0	0	Late delivery, milestone U/R		
Stack 1 to HB3	5/4	Y	0	0	Late delivery, milestone U/R		

G

No Significant Risk

Υ

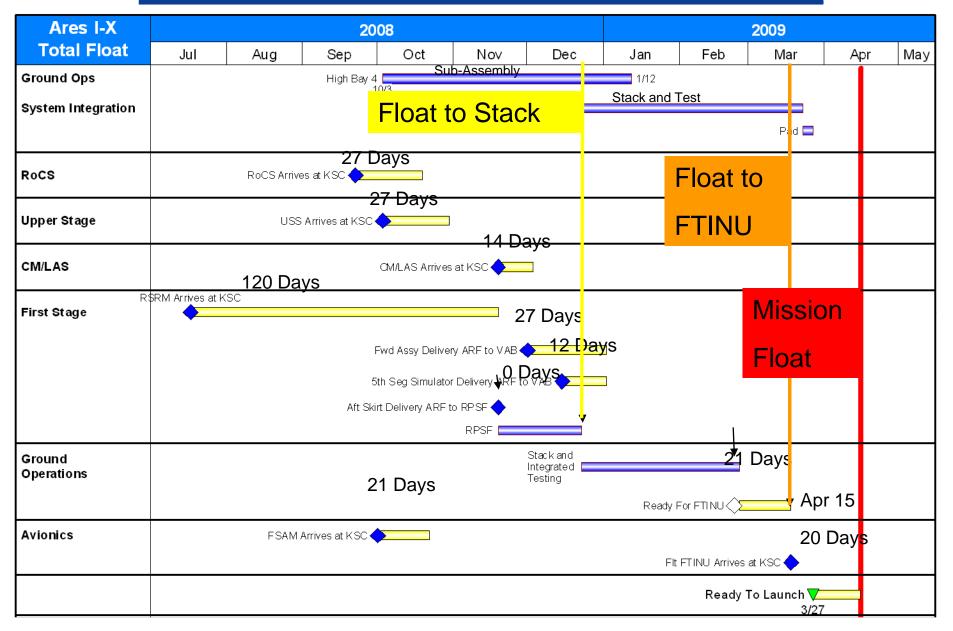
Significant Risk Identified that Threatens a Milestone

Unachievable, Impact to a Milestone



Communicating Total Float – Sample 1







Similarities: A Development Flight Test to a Development IMS



- Needed to stand up an IMS before CxP had established processes
- Scope creep The IMS had to resist or adopt change much like the rocket
 - Rocket
 - Added requirements from CxP
 - Sensor additions/deletions
 - Established processes from Centers
 - Requests to "try out" new software tools or processes
 - IMS
 - CxP wanted to try new processes out on us or even impose requirements
 - Primavera Pilot wanted us to use more of the tools than we needed
 - Centers had process that may have been incongruent with needs of I-X
- Had to be successful but still learn something

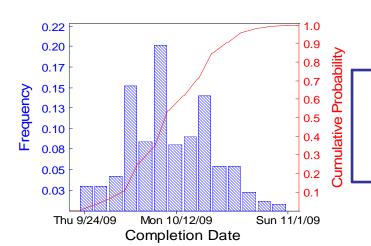
A proving ground that had to be successful



Monte Carlo – Use With Caution



- Started using Monte Carlo a few months after CDR
- Can approach diminishing returns K.I.S.S.
 - Use a separate, high level network (no open ends, no constraints)
 - Keep it simple and do not burden the whole team
 - Do analysis in small team, close to Project Manager
- Focus on Top Critical Paths & Risky Paths
- ◆ Results May learn more in the journey than the destination
- Attack the tasks with most uncertainty (Tornado Chart)
 - Success Story Integrated Testing → Duration 2 wks to 8 wks



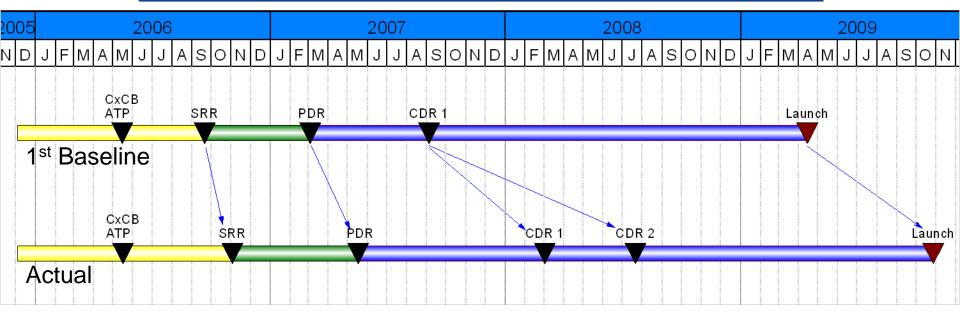
Garbage In → Garbage Out

It's a tool and not an exact science



Raw Data





- ◆ 18% schedule growth after CxP Authorization to Proceed
- ◆ Managed to the 4/15 Launch date for 2 years
 - Started with 0 Margin



IMS – Good Practices



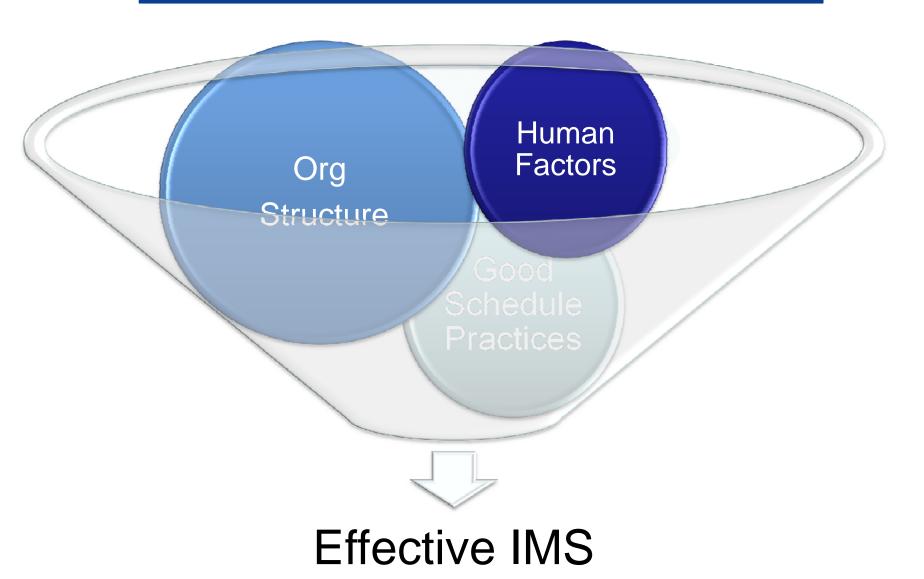
- ◆ The IMS is owned by the Team not the schedulers
- Schedulers should have a technical background and engineers should understand scheduling
- Manage the margin & float at as high a level as possible
 - Discourage use of margin at lower levels
- Lean Events (Kaizens) are terrific tools
 - Use early and often
 - Do it right don't cheat yourself
- Manage using Total Float Paths (requires a healthy schedule)
- Start using Monte Carlo Analysis just before CDR
 - It is just a tool and not an exact science
- Fancy software does not integrate a schedule
 - Enterprise tools are great when used by a good schedule team

BUT... Don't forget how important Human Factors & Org Structure is to the IMS



More Than Good Scheduling







Thanks to the Ares I-X Schedulers



Amy McQuown Nick Kindred

Brian Schmid Paul Mc Masters

Chris Feagan Paul Kuhlken

Dan Healey Sonny Wood

Doug Pulling Steve McGraw

Jackie Cochran Susie Johnston

Kathy Drummond Tracy Kamm

Karen Russell Tammy Donaldson

Lloyd Johnson Viren Harris

Melanie Hawkins



Big Shoes







